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THE PARAMETERS OF AN OPERATIONAL MACHINE TRANSLATION SYSTEM

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The use of machines to do high-volume, high-speed translation from one natural language to another is rapidly approaching operational capability. There have been many claims and counter-claims by several of the centers of research in machine translation published in the press, and, as is usually the case, there is some truth in each of these statements useful to our purpose of defining the operational parameters. In this paper I propose to discuss the current requirements for machine translation and the data base which can be used to come to final decision concerning these parameters. I do not intend to recite the historical development of the field except as this experience is useful to the purpose of this discussion since that chore has been well done by the Committee on Science and Astronautics of the U.S. House of Representatives.*

THE STATE OF THE ART

There are two principal schools of thought concerning the development of machine translation. The first has few advocates, but the few are very articulate. This group maintains that we must first concern ourselves with the design of special machines to do the translating. The other school believes that general purpose computers can be used for some time to come for both research and production in machine translation. Incisive inquiry resolves this dichotomy to the conclusion that the former group believes the problem of MT to be a machine one, while the latter believes it to be a linguistic problem. I count myself in the linguistic group.

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* U.S. Congress. House, House Report No. 2021, 28 June 1960.

There is disagreement between the so-called "pure research types" and those of us who believe that the need for machine capability is so urgent that we are willing to be satisfied for the time being with finding a routine that works reasonably well and whose operations are based on potentially transcendent concepts.

There are some who believe that a machine should be able to turn out a grammatically and syntactically perfect product before we attempt production. It seems strange that a machine should be expected to turn out translations which require no editing or revising when human translators can not. There is no translation facility in the government or elsewhere known to me which does not use a review process for polishing its product and assuring meaning transfer. Although a few brave souls have tried to assign percentages of adequacy to machine translated materials, they have never been very successful in relating their percentages to a base which was constant. In another section of this paper I shall put forth some experience which I believe will form a constant base for evaluation.

Because my task here is to talk about operational capability, I shall not speak to the theoretical research being so ably carried on by several research centers, rather I shall now make a categorical statement that in my opinion, based on association with machine translation research since 1952, the United States can look forward to an acceptable machine production capability in 6 to 10 disciplines in a year's time.

The Air Force program has a general vocabulary now in being, which is able to make word-by-word translations from Russian language newspaper text. Our program at Georgetown University under Prof. Leon E. Dostert is now capable of translating from Russian randomly selected texts in organic chemistry and very soon will be able to accept texts in economics. By early spring 1961 we shall have vocabularies in physical chemistry, geophysics, high energy physics and solid state physics to add to our present lexical repertory. The computer program at Georgetown is being changed over from its original form for the IBM 705 computer to the IBM 7090. With the vocabularies in the six disciplines listed above, we expect to have turned out by mid-1961 about 6 million words of text which have never before been translated and which were not used in the development of the MT program.

Although I postulate the state of the art of machine translation to be of a sufficient level to warrant operational machine translation production from Russian-language materials, I do not wish to suggest that all problems in the transference of meaning from one language to another by machine have been completely solved. Further, although I am considered one of the strongest advocates of an operational machine translation system now, I wish also to be counted as one who would raise his voice in support of any meaningful research which would continue the upward trend in quality of the machine translated output.

THE MAGNITUDE OF THE TRANSLATION PROBLEM

Our most immediate concern is with the translation of the Russian scientific and technical press for the benefit of the American scientific community and through it the national security. With the availability of this material in a form usable by the scientist in this country who has no capability in the Russian language, we shall be able to appraise the present state-of-the-art and the probable directions of scientific research in the Soviet Union. In our early planning for the establishment of operational machine translation, we reviewed the scientific literature output of the USSR for 1958. These findings are summarized in the table below.

Table I

Soviet Scientific & Technical Publications for 1958*

Scientific Field		Words
Physicomathematical Sciences		80, 255, 000
Chemical Sciences		26, 015, 000
Biological Sciences		40, 968, 000
Geological-Geographical Sciences		85, 515, 000
Medical Sciences		153, 948, 000
	Subtotal	386, 701, 000
Engineering-Industrial		488, 375, 000
	Grand Total	875, 076, 000

If even half of the scientific material were worth translating, we would have a total load of over 1 million words per day for every day of the year. The question has been put to me several times as to who would read all of this material. This question is an absurdity, since no one person would want to read all of this output under any circumstances, any more than anyone would wish to read all the books in the Library of Congress. The real benefit lies in making the material available soon after publication without the ordinary delays of getting translations made by human effort. No one wants all this translated material, but everyone wishes to be able to select from it.

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* Source: Accumulation of data from 1958 issues of Letopis' Zhurnal'nykh Statey (Annals of Journal Articles) and Knizhnaya Letopis' (Book Annals).

It may be interesting to note that a scientific linguist working full time on the translation of Russian material is able to translate only about 1800 words per day. With existing and forthcoming machine programs, it is or will soon be possible to translate up to 50, 000 words per hour and as the programs become refined and as more efficient methods of input and output are developed, there seems to be no reason why this rate could not be increased to between 150, 000 and 200, 000 words per hour.

THE PARAMETERS OF INPUT

At the present time all machine translation research centers are using either punched cards or punched paper tape as the input medium. Our experience with the preparation of punched cards has shown that a first-class card punch operator is able to prepare about 9000 words per eight hour shift with an extremely low error rate. As a matter of fact although these card punch operators had had no previous experience with Cyrillic alphabet materials, with minimum training they were able to achieve error rates which were lower than the rates demonstrated by operators who were transcribing materials in Latin alphabet. In order to satisfy the input requirements for our suggested million-words-a-day production, a staff of more than one hundred card punch operators capable of the production rate described above would be needed. Our experience with punched paper tape has been that although a paper tape machine operator will turn out higher production on a short test, over the longer range of a continuous eight hour day the card punch operator will turn out approximately 14% more material ready for the machine. The explanation for this situation lies in the fact that the correction of errors on punched cards is considerably simpler and less time consuming than the correction of error on paper tape.

The ultimate in our present horizon of input capability is the early development of a machine which will read directly from original text and translate that original text from its printed form into a digital machine language acceptable by the computer. The present state of development of reading machines suggests a rate of input of approximately a hundred words per second. This rate is completely acceptable and compatible with the translation rates which we have suggested to be the optimum in computer equipment now in being or contemplated. The principal problem as yet unsolved is the transcription of graphic representations on a page of text. The training of a reading machine to recognize graphic materials and the routines to place these graphic materials correctly in the output text remain to be developed. As an interim measure we shall have to be satisfied with a reading machine which will input textual materials at a net rate of 50 words per second and then we shall manually insert the graphics as they should appear in the output text.

The parameters of input then call for a capability to feed the machine fifty words a second - a capability which appears to be in the immediate offing - and an ultimate input rate of 100 words per second.

THE PARAMETERS OF TRANSLATION

As mentioned above there are some who will argue the value of the special purpose computer for machine translation over the use of the general purpose computer. I have no doubt that at some time in the future as the methods of machine translation become more and more refined we shall find it desirable to have a special purpose, linguistic computer built. However, at the present time there appears to be no reason why such a special purpose machine is necessary. There are many computers capable of doing machine translation available in the United States at the present time. As routines and programs are developed for these various brands of computers, it will be possible for institutions or firms having such machines to do their own automatic translation when their requirement for such translation does not even approximate that which would justify the acquisition of a special purpose, linguistic computer. Therefore, I conclude that for the time being the general purpose computer will be quite adequate for the planning for an operational machine translation capability.

The reliance on table-look-up as opposed to algorithmic programs does not contribute either to efficient or economical machine translation. If all of the paradigms of a language must be maintained in table form, there is a great expense in memory. On the other hand the use of algorithmic routines will permit the storage of only the stem form of words with the computer carrying out the necessary logical analysis to identify the morphology and the function of a word in a sentence. For the time being it seems to me to be desirable that both the table-look-up method and the algorithmic method be pushed forward with deliberate speed so that sufficient evidence can be assembled to permit a decision as to which of these methods is superior.

There are some workers in the field who have insisted that the responsibility for determining the quality of translation lies with the MT research personnel. I believe that the only meaningful criterion which can be applied to machine translation, or human translation for that matter, is the effective transference of meaning from one language to another. To satisfy ourselves that this transference of meaning was in fact taking place, an experiment was conducted using a single observer who was qualified in both the Russian language and the substance of the material under discussion. He examined the machine output sentence by sentence and compared the translation with the original Russian text. His findings were that there was effective meaning transfer. We then undertook a more extensive research program in which a similar analysis was carried out by a group of about one hundred scientists broken up into four groups. The first group had substantive knowledge of the material which had been translated and also Russian language capability. The second group had knowledge of the discipline, but not the Russian language. The third group had the Russian language capability but no expertise in the substance. And the fourth group had neither knowledge of the Russian language nor of the discipline of the test materials. The summary results of this experiment showed that in the case of the first group full meaning transfer had taken place and the translated text was acceptable. The second group, whose grasp of the discipline was good but whose language capability was slight or non-existent, found more difficulty sorting out the meanings in lexical gaps, but they still found meaning transfer to be recognizable. Frustration was apparent with the two groups whose knowledge of the substance was either absent or minimal - frustration which at times manifested itself in condemnation of machine translation. Please note that all respondents who had knowledge of the discipline found the machine translation acceptable and usable. This, I believe to be the over-riding criterion.

THE PARAMETERS OF OUTPUT

At the present time the machine output is put onto magnetic tape and an off-line print-out is made. Under conditions of large scale production, this method may be unsatisfactory. There are in being, however, several devices which will permit high-speed and high-capacity alpha-numeric output from a computer. There remains only to determine the relative economics of the two methods - there is a limit to the number of off-line print-out devices one may use before the costs overtake the capital investment and operating cost of on-line equipment.

A great controversy has developed concerning the degree and type of post-editing required for the machine output before publication. There are some who are so naive as to think that a machine will be developed which can turn out machine translation not requiring post-editing. Those of us who have been concerned with translation of materials for some years, know that this is not realistic. In his book entitled "Cybernetics of the Present and Future" Yu I. Sokolovskiy, in discussing the quality of automatic translation from the Russian point of view states: "On the whole one may say that a machine translation needs approximately the same amount of editing as a man-made translation". In order to determine the qualifications of a good post-editor, we believe it necessary to carry on a series of experiments using actual machine output, and with people of varying qualifications, to arrive at some sort of reliable criteria for personnel selection. Such a program is now underway at Georgetown University.

AN OPERATIONAL MACHINE TRANSLATION CENTER

The first approximation of an operational machine translation center shall have available in it three principal equipment complexes. The first of these shall be the mechanical reading device which shall convert the printed form of literature into machine acceptable language. The second complex shall be the translator itself which, for the time being, can be a general purpose computer, but at some time in the future will probably be a special purpose computer. The third complex shall be the equipment necessary for accepting the output of the machine and converting it into printed form in as expeditious manner as possible. Because of the speeds which we believe practically obtainable, it does not appear necessary to contemplate the existence of more than one translation center for Russian language materials for the immediate future. However, as our capability grows and we are able to handle new languages and new disciplines, expansion of the center to greater capacity, or the creation of other centers to deal with other languages, may be desirable.

To review then - we must set up a center which will be capable of translating approximately 1 million words per day starting from the raw publication and ending up with a printed form of the output ready for post-editing. At the present time the rate-determining step in this enterprise will be the input step. However, with the development of reading machines, it is our belief that this step will not long remain a problem area.

CONCLUSION

Let us not ask of machine translation more than we have asked of other scientific developments in the past. The aircraft of 20 years ago was considerably slower and of shorter range than equipment in use today. But that fact did not interfere with the use of the then existing capability while new and better machines were developed. Let us remember that the greatest enemy of progress is perfection.